The sspm R package: spatial surplus production models for the management of northern shrimp fisheries

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Abstract

Productivity models such as Surplus Production Models (SPMs) models can be used to inform stock management of fisheries. However, those models often share three main flaws: (1) they are usually not spatially explicit, (2) fail to incorporate ecosystem predictors and therefore are ill-suited to ecosystem-based management of stocks, and (3) their deployment is often limited by code availability, quality and accessibility. To fill this gap, we developed a lag-1 autoregressive SSPM based on Generalized Additive Models (GAMs), broadly applicable to spatially-structured populations, and bundled into an R package. We applied this model to one of the most economically important invertebrate populations in Canadian waters, Northern Shrimp (Pandalus borealis) in the Newfoundland and Labrador Shelves. This stock currently lacks a population model to predict how fishing pressure and changing environmental conditions may affect future shrimp abundance in the region. Our model incorporates relevant ecosystem predictors for this stock, such as Atlantic Cod (Gadus morhua) density, alternate predator density, temperature, and stock biomass. In addition, the model is deployed through the R package sspm, a flexible framework aimed at making SSPMs easier to apply to spatially structured populations. The package allows for a repeatable and open workflow and improves the accessibility of SSPMs.

Summary

TBD

Statement of need

1. The Northern Shrimp stock in the Newfoundland and Labrador Shelves currently lacks a population model
2. Current SPM models are rarely spatially explicit and isually cannot account for relevent ecosystem drivers
3. Fisheries managers lack user-friendly, flexible tools to implement and apply Spatial SPMs

Introduction

(1) Modelling spatially-structured populations => of interest
(2) Especially of interest by fisheries models
(3) Process based models vs statistical models
(4) SPM models => but still lack ability to go about uncertainty

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35 (5) In this paper, we develop a model…

36 (6) We apply this model to the Shrimp Fishery (some background)

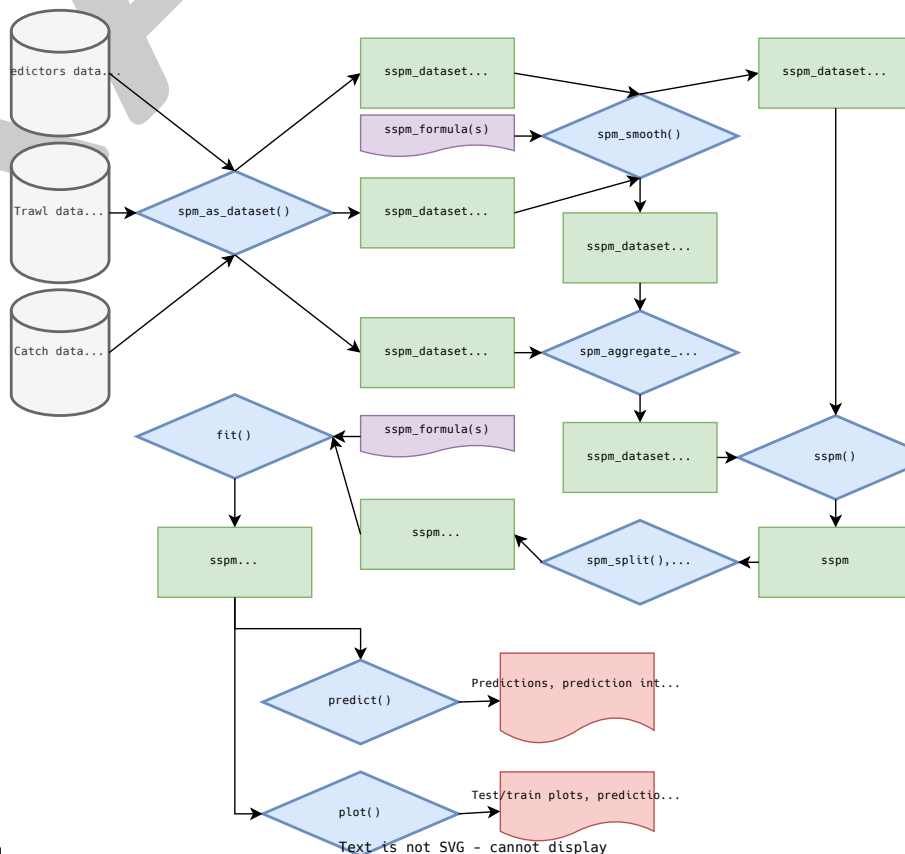37 (7) We make this tool flexible and user-friendly: This is an R package

38 Model

39 Rho => varying prod => covariance matrix => precision => basis functions and Gams

40 Results

41 The GAM biomass estimates are consistent with those of the current tool in use for the
42 assessment of the stock, Ogmap, and provide valuable insights about the drivers of the rapid
43 increase and decline of shrimp in the southern end of the shelf. Our approach demonstrates
44 the model's ability to become a useful tool for modelling spatially-structured populations like
45 fisheries stocks. The sspm package successfully modularizes each step of the modelling process
46 and implements a range of useful features for modeling spatially-structured populations: spatial
47 discretization, simplified GAM syntax, prediction intervals and scenario based forecasts for
48 longer-term trends. In a fisheries context, It illustrates how our model can be easily used by
49 managers to forecast fisheries productivity under different management regimes. The package
50 is also a tool to think about design choices when conceiving a user interface for managers and
51 on best practices when it comes to adapting research code into management tools. Finally,
52 our approach demonstrates how open source software tools can improve the accessibility and
53 reliability of models for fisheries management.

54 Package design

55 TBD => need a graph

Application to simulated data

Citations

Citations to entries in paper.bib should be in rMarkdown format.

If you want to cite a software repository URL (e.g. something on GitHub without a preferred citation) then you can do it with the example BibTeX entry below for Smith et al. (2020).

For a quick reference, the following citation commands can be used: - `@author:2001` -> "Author et al. (2001)" - `[@author:2001]` -> "(Author et al., 2001)" - `[@author1:2001; @author2:2001]` -> "(Author1 et al., 2001; Author2 et al., 2002)"

Figures

Acknowledgements

TBD

References

Smith, A. M., Thaney, K., & Hahnel, M. (2020). Fidgit: An ungodly union of GitHub and figshare. In *GitHub repository*. GitHub. https://github.com/arfon/fidgit